High-Speed, Real-Time, Ocean Bottom Optical Topographer

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LONG-TERM GOALS

Our research is directed toward utilization of modern optoelectronic technology for real-time 3-D mapping of the ocean floor. We strive to construct a compact instrument (ROBOT) capable of real-time imaging and classification of man-made and natural objects in a wide range of marine and freshwater environments. We expect that this work will have relevance to the in-water investigation and surveillance needs of branches of the U.S. Military, U.S. Intelligence agencies, as well as state and local law-enforcement agencies.

OBJECTIVES

The broad objectives of this work are the development of an improved version of our real-time ocean bottom optical topographer (ROBOT). We will expand the capabilities of our proof-of-concept system to work at higher vehicle altitudes (4-5m) and velocities (5-10 knots), while maintaining

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14. ABSTRACT
Our research is directed toward utilization of modern optoelectronic technology for real-time 3-D mapping of the ocean floor. We strive to construct a compact instrument (ROBOT) capable of real-time imaging and classification of man-made and natural objects in a wide range of marine and freshwater environments. We expect that this work will have relevance to the in-water investigation and surveillance needs of branches of the U.S. Military, U.S. Intelligence agencies, as well as state and local law-enforcement agencies.

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centimeter-scale spatial resolution. Overall system size will be reduced to permit use on a wider range of vehicles including the next generation of small (i.e. 8” diameter) AUVs.

APPROACH

This proposal is specifically directed to the re-design of our proof-of concept ROBOT system. Using data from deployments and flume testing as guides, we will alter the current design by increasing the light source power, increasing detector sensitivity by adding an image intensifier and repackaging the system for use on smaller vehicles. Our design modifications will be step-wise in nature. We will first add the image intensifier and characterize the change in performance. Next, the laser will be replaced, and again tests will be done to determine performance increase. Lastly, the new system components will packaged for use on smaller vehicles.

Key personnel: E. Kaltenbacher (Lead Engineer), J. Patten (Software Engineer), D. Costello (Ocean Optics Researcher), K. Carder (Lead Scientist) and Center for Ocean Technology Engineers and Technicians.

WORK COMPLETED

We have successfully added the image intensifier and replaced the current laser with a more powerful one. The first step was the addition of the image intensifier in front of our smart camera. We decided to use a Xybion IRO Intensifier for our project. These intensifiers have good sensitivity at our laser’s wavelength (532 nm), have integrated relay optics, and are self-contained. ROBOT’s detector housing required elongation due to the length of the intensifier. The primary imaging lens was replaced with one compatible with the sensor size of the intensifier. After the installation was complete, we tested the system in our 9000-gallon flume. We tested the system by viewing targets with different reflectivity values in varying degrees of turbidity. We recorded the maximum viewing distance and coefficient of absorption (c) for each level of turbidity. Results obtained with the proof-of-concept system were compared to the results with the intensifier modification (Table 1). The data (shown for an object with 22% reflectivity) indicate a significant increase in performance with the intensifier installed.

c (meters^{-1})	System Without Intensifier	System With Intensifier
0.3	2.0 meters	4.5 meters
0.5	1.4 meters	4.2 meters
0.75	0.9 meters	3.1 meters

Table 1: Flume Test Data

[table: Maximum viewing distance for system without intensifier is 2.0 meters at c=0.3 meters^{-1}, 1.4 meters at c=0.5 meters^{-1} and 0.9 meters at c=0.75 meters^{-1}. Maximum viewing distance for system with intensifier is 4.5 meters at c=0.3 meters^{-1}, 4.2 meters at c=0.5 meters^{-1} and 3.1 meters at c=0.75 meters^{-1}. Object reflectivity was 22%.]

After significant research, a suitable replacement laser was located, purchased and installed. We purchased a Lightwave Electronics laser that emits 440mW of radiation at 532 nm. This represents nearly an order-of-magnitude gain in light intensity over our current laser. This laser works well for our application because of its small size (2000 cm^3) and its ability to operate solely from regulated DC supplies. The laser installation required design and construction of a watertight housing to hold the laser, design of new electronics to drive the laser and software modifications for laser control. Tests are scheduled for late September to determine the performance of the system with the new laser.

RESULTS

We have successfully demonstrated an improvement in sensor performance over the proof-of-concept system. The image intensifier increased detector sensitivity almost enough to meet our goal of imaging lower-reflectivity objects from 5 meters away. It is anticipated that planned tests with the recently replaced laser will reveal that we will be successful in imaging targets from the 5-meter goal. We have also decided to pursue another detector arrangement.

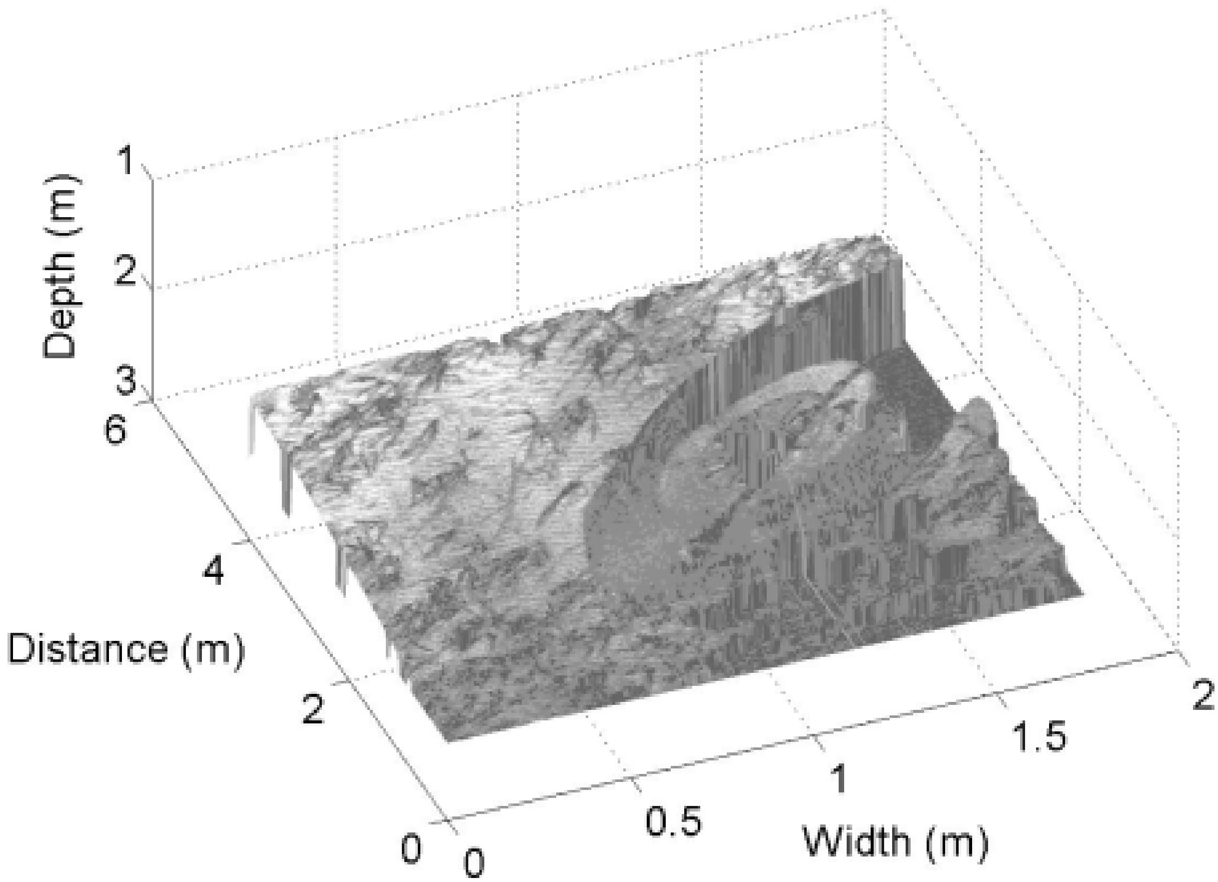

Figure 2: Manta Mine Simulant
[Isometric view of Manta mine simulant with albedo data imbedded in the height information.]

A new technology has emerged this year in CCD sensors. Marconi has released a camera based on their low-light-level CCD (L3CCD) sensor. This sensor is roughly 1000 times more sensitive than a standard CCD camera, but it is not susceptible to damage from bright sources, as intensifiers are.

Testing indicated that the specialized CMOS camera we are currently using is not very sensitive and some of the gain introduced by the intensifier is lost by this lack of sensitivity. We will therefore replace the intensifier/camera combination with the L3 camera. It is expected the overall light sensitivity will be as good, if not better, with this approach. Also, this camera will more readily permit development of custom image processing routines, which is a major portion of our effort planned during the next funding period.

Another development this year is the ability to simultaneously display 3-D and albedo data. Working with data collected with our proof-of-concept system, we created the image shown in Figure 2. These data are from a Manta mine simulant placed in the test range during the 2000 Coastal Optical Benthic Properties (CoBOP) exercises. This image highlights the usefulness of recording simultaneous range and intensity data. Object identification and classification can be facilitated with data such as these. Data describing the surrounding terrain may also be helpful in locating identified targets.

IMPACT/APPLICATIONS

The ROBOT instrument presented in this work can be used to accurately provide bathymetric and albedo information of the sea floor. Applications of this sensor include object detection (e.g. mines, coral) [5] , contour mapping (e.g. sand waves), and crash site investigations. These data can also be used in shallow coastal waters to ground-truth remote sensing data[Carder et al. in-press]. Use of this sensor includes both marine and freshwater environments. Our instrument is simple, portable, relatively inexpensive and suitable for use on a wide variety of platforms.

TRANSITIONS

The technology development in this work can be extended to analysis of terrestrial areas considered too dangerous for human investigation. This instrument can analyze debris and other aspects of crime scenes or other hazardous areas. Local law enforcement agencies have expressed interest in utilizing ROBOT for in-water forensics. We have also made contact with U.S. Coast Guard regarding utilization of ROBOT for port security as well as an upward-looking version for security scanning of ships' hulls and are in contact with the Federal Bureau of Investigation (FBI) about possible opportunities for this work.

RELATED PROJECTS

Data gathered by ROBOT has been used in conjunction with multi-spectral seafloor images produced by the Ocean Optics Group at the University of South Florida. It is expected that joint work with the Ocean Optics Group will continue with the addition of their sensitive fluorescence imager.

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